Interdisciplinary Research Programs in Geophysical Fluid Dynamics

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LONG-TERM GOALS

The long term goals are to train new scientists to conduct research, and to enhance the abilities of experienced research workers in geophysical fluid dynamics.

OBJECTIVES

To help graduate students formulate and tackle innovative research problems in GFD. To promote an exchange of knowledge and ideas between investigators in the different scientific disciplines that deal with the dynamics of stratified and rotating fluids. To formulate tractable, important problems which are presently at the fringe of our understanding in the field of Geophysical Fluid Dynamics. To serve as a clearing house for the mathematical, experimental and computational techniques which serve astrophysics, climate science, geodynamics, meteorology and oceanography.

APPROACH

We conduct a summer study school of ten weeks duration each summer. The participants are graduate student fellows, visiting graduate students and visiting scientists. The first two weeks consist of principal lectures in the summer's topic conducted by an expert in that area. Lectures by associated participants follow at a rate of roughly one or two per day for the remaining weeks except for the last week, when student fellows present their results. Approximately ten graduate students are admitted as Fellows. Each Fellow receives a stipend for the full ten weeks, conducts a research project under the guidance of the staff and provides a written project report. The fellows also write up the principal lectures. Several other graduate students visit for shorter periods to listen to lectures and interact with the staff. The staff (*i.e.*, all of the visiting scientists) is continually renewed by inviting new participants from the various disciplines with an interest in rotating, stratified fluid flows. Most of these participants receive partial support from the program. Continuity is provided by a small group of participants who attend regularly (once every two years or more frequently). Little direct support is provided to this latter group. The lecture notes and the written report of the fellows' projects are contained in a volume which will be distributed in print form and put on the Web.

WORK COMPLETED

This year, the program topic was the General Circulation of the Atmosphere. Rick Salmon of Scripps Institution of Oceanography was the director and Isaac Held of the Geophysical Fluid Dynamics Laboratory at Princeton University was the principal lecturer.

The motivation of the topic was due to the fact that at large scales, the Earth's atmosphere and oceans obey nearly the same equations, but the atmospheric circulation differs greatly from its oceanic counterpart. To leading order, the average atmospheric flow is a zonal flow swirling around the poles, slightly perturbed by the asymmetry of the continents and oceans. In the ocean, coastlines prevent zonal swirl at nearly all latitudes; only around Antarctica is the ocean free to swirl. The symmetry of zonal swirl is directly responsible for recent and significant progress in understanding general atmospheric circulation. Theories utilizing the concepts of pseudomomentum, Eliassen–Palm flux, and wave-driven mean flows have been successful primarily because of this fundamental near-symmetry. These concepts were thematic in the two- week introductory course given by Isaac Held, which was strongly supported by lectures from Alan Plumb (MIT), Wayne Schubert (Colorado State), Michael Cullen (ECMWF) and Oliver Buhler (St. Andrews College).

A principal goal was to bridge the gap between numerical modeling and theoretical understanding. These two activities — modeling and theorizing — are presently seen as almost completely unconnected, but theory should guide the construction of models, and model results should spawn theories. As usual, we had a variety of seminars throughout the weeks following the lectures, covering the many subjects in which mixing and stirring plays a role. Week 4, organized with great success by Jim Ledwell (Woods Hole Oceanographic Institution), focused the attention of the participants on the oceanic problem. Several visitors came to participate solely in this week.

The nine fellows selected this year were selected from a pool of applicants who are graduate students in their second to forth year from many disciplines. The fellows, their affiliation, and their report titles this year were:

Tivon Jacobson, New York University, “Longshore Currents, Vorticity Dynamics and Barred Beaches”

Christopher Walker, University of California, Irvine, “What Makes Oceanic Gravity Currents Flow Downhill?”

Christos Mitas, University of Illinois, “Eddy PV Fluxes in a One-Dimensional Model of Quasi-Geostrophic Turbulence”

Cheryl Lacotta, University of Arizona, “Can a Simple Two-Layer Model Capture the Structure of Easterly Waves?”

Karen Shell, Scripps Institution of Oceanography, “Super-rotation in an Axisymmetric Shallow Water Model of the Upper Troposphere”

Giulio Boccaletti, Princeton University, “Monsoons in a Moist Axially Symmetric Model of the Atmosphere”

Zhiming Kuang, California Institute of Technology, “A Truncated Model of Finite-Amplitude Baroclinic Waves in a Channel”

Christian Sonekan, University of Charleston, “Experimental Investigation of a Theory for Oceanic Convection”

Lucy Campbell, McGill University, Canada, “A Quasi-Biennial Oscillation Generated by Gravity Wave Breaking”

Approximately twenty five other visitors came from many disciplines and stayed for varying lengths of time from one day to ten weeks. Staff is comprised of various visitors who return to the program each summer. All are research workers or faculty members.

With support from supplemental funds to this grant, a number of new computers were purchased and have been tied together in an integrated system. The building and computers are fully connected to the world-wide web and many staff and fellows use supercomputers elsewhere for advanced computations. A number of features, such as a list of past fellows, the titles of the lectures, a list of participating scientists, and recent past volumes, are listed on the web at http://www.whoi.edu/gfd. Eric Chassignet, Glenn Flierl and Jean-Luc Thiffeault must be thanked for their important contributions to overseeing the computer facilities and creating this year's volume.

RESULTS

The principal lectures and fellows' reports are the tangible results. They are available as a technical report and on the web

IMPACT/APPLICATIONS

The experiences of the fellows and the staff are difficult to quantify. Many express their enthusiasm at the end of each summer. We conducted a survey last summer for the past 20 years of fellows as part of the celebration of the 40th year of the program. About 80% of the remarks were highly complimentary. Some fellows had serious suggestions for improvement. A few of the roughly 50 responses are given here:

“I benefited a lot from the school. And overall the experience was invaluable. My criticism was that I sometimes felt that the emphasis was too heavily based on getting results (namely graphs of numerical simulations) rather than education. I found this a little bit stifling because I had open ended ideas that I wanted to explore. And I know that the help of the staff in developing these ideas with would have been very educationally valuable to me. But, towards the end I was strongly encouraged to do things that I already knew how to do, which had less educational benefit to me.”

“The GFD program is a great educational experience which introduces many talented future scientists to our field. We should make every effort to make sure it continues for many generations of new scientists. Adding more visiting lecturers can be beneficial to all.”

“The GFD faculty was, taken as a group, as good as or better than the best department anywhere. It was a real treat to be a student/fellow of this group.”

“The most valuable lesson for me was watching this accomplished group ‘do science.’ I learned more from interacting with them, and watching/listening to them interact with one another and with other fellows than from any specific problem or piece of research.”

"I chose the wrong project with the wrong advisor. I didn't get much out of the summer. But, in a different situation, I definitely would have."

TRANSITIONS

We estimate that typically 20–50% of the student projects become included in their thesis or postdoctoral work and/or result in publications. The program does not follow the fellows' research after the summer is finished although individual staff members often remain involved with the fellows' continuation of their projects past the end of the summer.

RELATED PROJECTS

All staff members are active research workers, so numerous related projects exist.